EV to Grid Ecosystem Mapping

July 2022

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Glossary of terms

Term	Description
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
CEFC	Clean Energy Finance Corporation
CPO	Charge point operator
DEIP	Distributed energy integration program
DER	Distributed energy resource
DNSP	Distribution Network Service Provider
DOE	Dynamic operating envelopes
ENCRC	Energy National Cabinet Reform Committee
ESB	Energy Security Board
EV OEM	Electric vehicle original equipment manufacturer
FCAS	Frequency control ancillary services
HEMS	Home energy management system
NEM	National Electricity Market
NRMA	National Roads and Motorists' Association
RACE for 2030	Reliable, Affordable, Clean Energy for 2030
REVS	Realising electric vehicle-to-grid services Australia
SA	South Australia
SAPN	South Australian Power Network
TCO	Total cost of ownership
TNSP	Transmission Network Service Provider
V2G	Vehicle to grid
V2H	Vehicle to home
V2L	Vehicle to load
VPP	Virtual Power Plant
ZEV	Zero emissions vehicle

SECTION 01 : Executive summary

Who and what needs to be influenced to transform the Vehicle to Grid ecosystem?

RACE for 2030 engaged Evenergi to identify the causal pathways to transformation in relation to the Electric Vehicle (EV) to grid ecosystem and to understand who and what needs to be influenced to cause this transformation to occur. This ecosystem includes the options of basic charging management to support demand response, Vehicle to Home (V2H) and Vehicle to Load (V2L or V2X) as well as Vehicle to Grid (V2G) - all of these being ways EVs and the grid can integrate to ultimately lower energy costs.

This work leverages previous RACE for 2030 (RACE) research, opinions gathered from experts across the ecosystem, including those of Evenergi, and supplementary research.

The key conclusions from this work were:

1. Irrespective of how the ecosystem evolves, adoption is reliant on EV owners seeing value integrating with the grid. For many, this will be heavily weighted on financial benefits, and this will likely require subsidisation until economies of scale are reached. This makes **state and federal governments** a powerful influencer of uptake rates for participation in the grid integration and a high priority target for RACE to influence with their research.
2. Complex rules and a lack of standardisation for technology that facilitates the integration of EVs into the grid, make it very difficult for Original Equipment Manufacturers (OEMs) and energy retailers to create streamlined and cost effective solutions. Research RACE is conducting into standards for EV charging and communications will be valuable to market bodies such as the **Australian Energy Market Operator, Energy Security Board, the Australian Energy Market Commission, Energy Networks Australia and the Clean Energy Council.**
3. The technology is largely already developed, and is mostly waiting on market demand before OEMs start bringing products to market. We do not see the OEM market as a valuable sector for RACE to focus its transformation efforts in.
4. Retailers are largely waiting on a market, with enough trials and pilots already underway to refine their understanding of the needs of EV.
5. Market demand relies on educated customers who understand the benefits of V2G. The research RACE is conducting into the benefits of V2G and how to manage potential accelerated battery degradation would be worth sharing with bodies that have a connection to **EV owners** such as large fleet owners (government for example), EV OEMs and the Electric Vehicle Council.

The following pages summarise the answers to the questions posed as part of the scope of this study and provide a more granular view of who and what needs to be influenced to drive transformation across the EV to grid ecosystem.

Where and with whom RACE can maximise the impact of their research

The RACE research themes noted within this section can be found in the report titled "N1 EV Opportunity Assessment Report FINAL_0511202", which can be found on the RACE for 2030 website. The research themes referred to are tabulated on pages 7 and 8.

Table 1: *Where RACE's EVs and the Grid research would make the most impact*

Sector of Influence	Key Actors	N1 Research Roadmap
Government Funding Agencies 	ARENA State Gov. Climate Dept's AER	Research which demonstrates the community value of V2G and would warrant a significant investment by the government to cultivate grid integration of EVs. Data & Technology - EV trials with whole of network approaches Integrated Opportunities - New EV/Grid Business Models
Regulators 	ESB AEMC ENA CEC	Research which influences the uptake of internationally approved standards with national consistency. Integrated Opportunities - Exploring regulatory and other constraints associated with the integration of energy, e-mobility and development Regulatory and Coordination - Standards and protocols for bi-directional chargers, interoperability protocols and communications
DNSPs 	SAPN, Ausgrid Evo, Mondo etc	Influence more than specific research to ensure their governing bodies enforce them to adopt consistent national standards rather than DNSP specific. All above research categories for Regulators apply plus Market and Pricing - Tariff design
EV Owners 	Government Ministers EVC	Research which informs customers perceptions of V2G and helps them understand the pathway to participation. Data & Technology - Charging Implications and EV Data Customer & Culture Behaviour
Retailers 	ActewAGL Ovo Octopus	Research which helps them refine offerings to EV owners. Noting though this is deemed helpful, but not as essential as some of the above stakeholder to influence.

Who is involved in the causal pathway to transformation?

The following diagram highlights the sectors that have a role in the EV to grid ecosystem, our view on their level of influence (vertical axis) and their solution focus (horizontal axis).

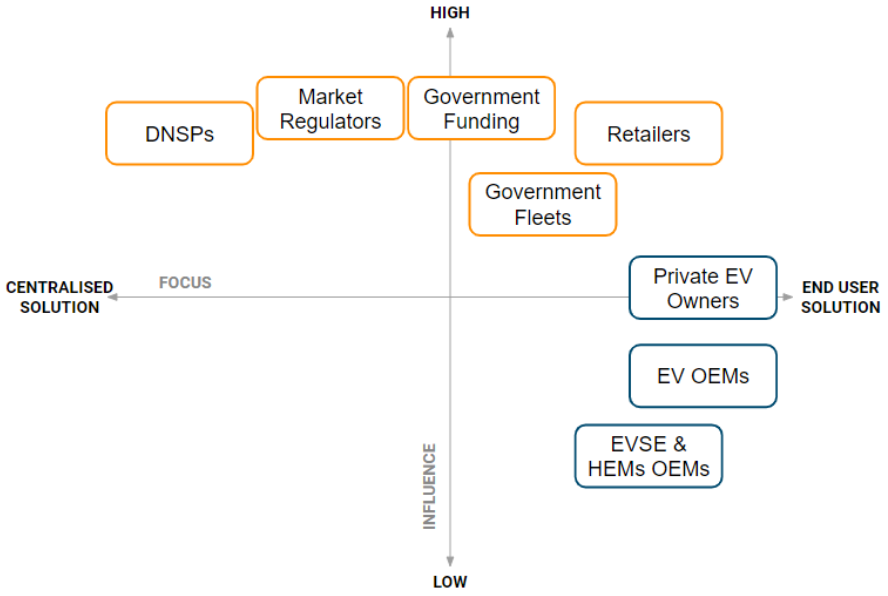


Figure 1: *Overview of the EV to Grid ecosystem sectors, their influence and focus*

The key takeouts at this high level, which are in-line with previous RACE research are:

1. Incentives will significantly assist uptake of V2G technology and enable the ecosystem to reach economic scale making government bodies with funds key;
2. Regulators and DNSPs are critical to create a much more seamless and efficient process for EV to grid integrators to operate within - essential ingredients to create value, competition and innovation;
3. Retailers and innovative solution providers will be important in bringing the smarts required to create solutions seen as attractive by EV owners and creating uptake of V2G services; and
4. While all EV customers will ultimately be a target and important to engage with, government fleets are seen to be a large and socially minded fleet making them an ideal place to initiate and prove solutions.

Where is RACE best placed to put its efforts to achieve transformation?

Within each of these sectors there are certain actors which are already showing an eagerness to pave the way for enhanced EV to grid integration. These are the actors we recommend RACE for 2030 partner with to gain the maximum value from their market transformation activities.

The map on the following page shows the actors within each sector. The closer an actor is to the centre of the map, the greater their influence and likelihood to be a valuable entity for RACE to interact with.

Figure 2: *Actors within the EV to Grid ecosystem and their level of influence (closer to centre = greater level of influence).*

Table 2: *Overview of most influential actors in the Grid to EV ecosystem*

Sector of Influence	Key Actors	Focus recommended for RACE
Government Funding Agencies 	ARENA State Gov. Climate Dept's AER	RACE will need to use its research into the benefits V2G can have on grid capacity, increased renewables penetration and power quality to ensure V2G is supported. We see opportunities for direct funding support for V2G technologies and services through governments or indirectly through AER allowances given to DNSP's to support such programs.
Regulators 	ESB AEMC ENA CEC	We recommend RACE get involved with the regulators developing these rules and standards for connection of V2G chargers to the grid and for aggregated storage provision of AEMO Ancillary Services and use its research to help influence decisions towards those that support easy market entry and uptake versus making it easier to operate the grid using today's paradigms
DNSPs 	SAPN, Ausgrid Evo, Mondo etc	As the other side of working with the AER to secure funding we see a role for RACE to help support DNSP's in making their cases for engaging in activities which accelerate the uptake of integrating EVs into the grid.
EV Owners 	Government Ministers EVC	We believe government fleets provide an excellent starting place and RACE should focus on helping Transport and Sustainability Ministers understand the benefits of adopting V2G and how this could happen. General owner awareness is not an area for RACE's activities. They should be driven via public campaigns and via entities representing owners.
Retailers 	ActewAGL Ovo Octopus	We expect retailers will know what they need to make solutions attractive to customers and we see them as a good barometer of how well changes to the technical environment are working. RACE should form relationships with the Retailers most keen on V2G as a way to refine what is needed most to make the ecosystem thrive.

What are the most effective pathways for RACE for 2030's research to deliver the most impact considering impact, cost and equity?

The project considered three different causal pathways, each mimicking different rollout pathways for similar technologies. The different pathways highlight different ways in which the ecosystem could evolve, where this is most likely to take the ecosystem, and who drives this evolution.

By considering all three scenarios we can assess how RACE can use its research to most effectively influence the evolution of the ecosystem and ensure the solution provides the best and most equitable solution for the entire community.

All three scenarios showed the potential to reach a point where the EV to grid ecosystem thrives and adds value to EV owners and to the grid. We also expect elements of all three would exist in the real ecosystem. The differences here are pronounced to draw out which actors' influence is most aligned to what RACE wants to achieve.

Scenario 1: Retailer-led transformation (as per VPP market)

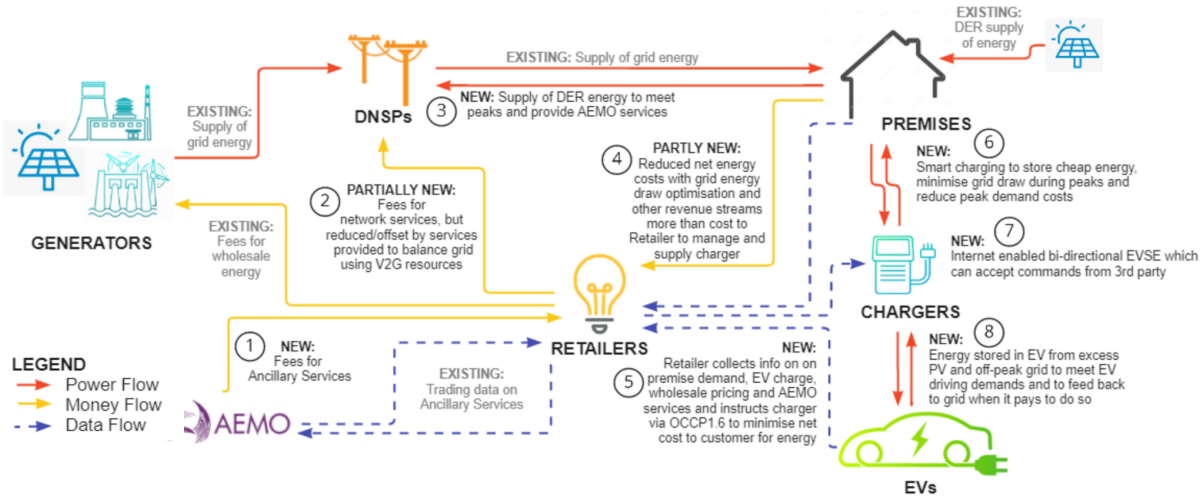


Figure 3: *End-state solution of EV to grid ecosystem driven by retailers*

Under this scenario the Retailer builds the service, taking on the complexity and risk of optimising energy arbitrage and services to DNSPs and AEMO to offer the EV Owner a net lower cost of energy for their total consumption.

This ecosystem provides a simple solution to EV owners, and would benefit the grid in ways which benefit the whole community.

The key elements required to initiate this ecosystem are the backbone rules and regulations to enable a new retailer to efficiently gain approval to provide services to DNSPs and AEMO and to have a strong availability of compliant bidirectional chargers they can communicate with to operate across Australia.

Utilising RACE's research to focus on getting rule-makers to agree to Australia-wide standards that align to international markets would be where it would gain the most impact.

Building consumer demand by using research to build the need for retailers to fill would also be a highly impactful use for RACE's research.

Scenario 2: Government incentive-led transformation (as per PV market)

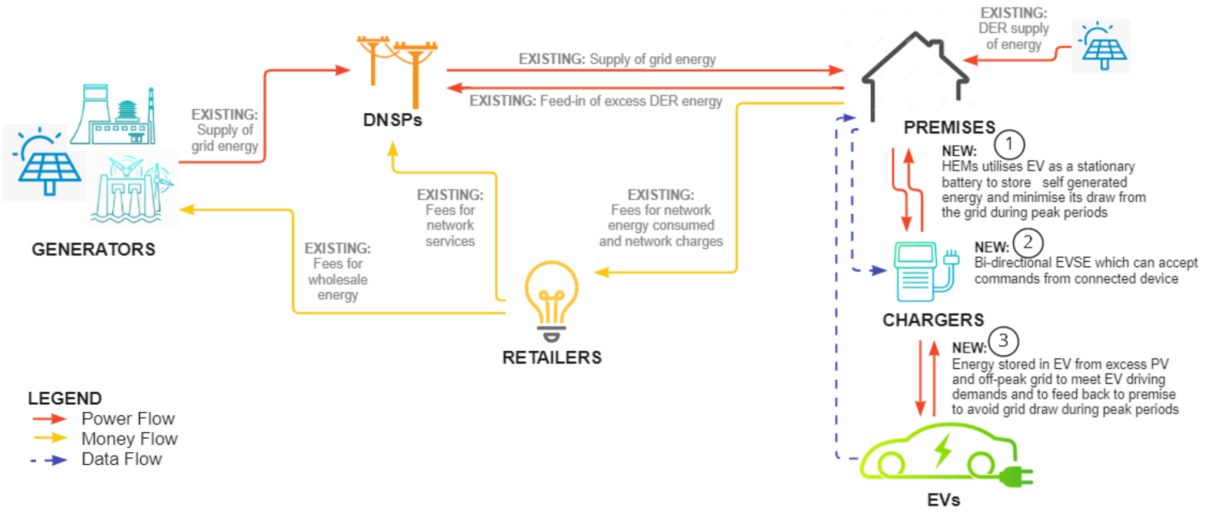


Figure 4: *End-state solution of EV to grid ecosystem driven by government incentives*

Under this scenario V2G uptake is triggered simply by generous incentives making the gap small enough that anyone considering a smart charger would choose a bi-directional one.

This ecosystem suits the independently minded EV owner, leaving them fully in charge of how much or little they use their EV as a means to store and discharge energy.

It would provide some benefits to the grid, but not as much as the other two scenarios developed and so we do not see it as the ideal solution for RACE to push to get the largest equitable impact from EV integration to the grid.

This means when working with the government to gain funding support for EV to grid solutions RACE should use its research to point out the greater benefits achieved by full V2G and influence governments agencies to structure incentives that are more likely to promote full V2G solutions.

Scenario 3: DNSP-led transformation (as per South Australian PV regulations)

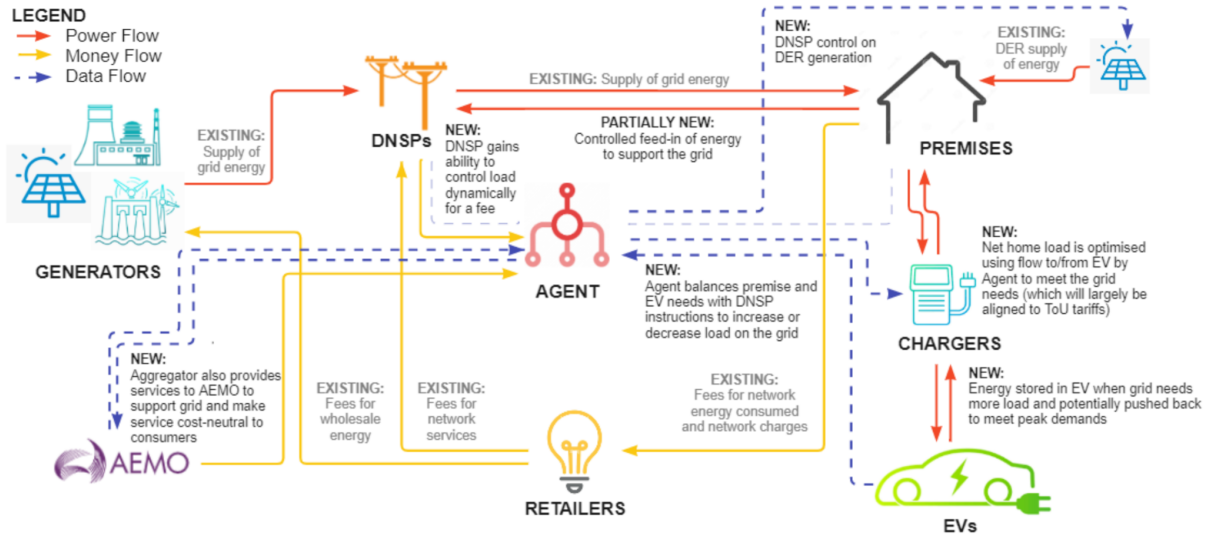


Figure 5: *End-state solution of EV to grid ecosystem driven by DNSPs*

Under this scenario charging and discharging windows of the EV are controlled by the DNSP (as is PV solar in SA) to raise and lower grid level demand to best suit the overall network. While most of the time, this would result in similar outcomes to Scenario 1, it has subtle differences such as it might have an EV charge faster than solar on the premise can supply to soak up solar from other properties where a premise-based optimisation may charge slower and only use its own solar generation.

Being mandatory it would result in the highest take up rates, even if it caused more angst and maybe a small degree of delay in initial charger uptake. Higher uptake would mean more potential to save large capital upgrades on the grid, and the whole-of-grid focus would also support this.

It makes this ecosystem an interesting one, which RACE may or may not find attractive to promote - it probably has the highest ability to create impactful and equitable change, but lowers consumer choice and freedoms.

If RACE were to want to pursue such a end-state ecosystem then the key to a efficient system would be ensuring DNSPs in each jurisdiction use the exact same control protocols and processes and have a centralised connection approval process for associated devices so solution providers can efficiently enter the market in more than one DNSP's jurisdiction.

RACE would want to use its research to guide these standards with the bodies that sit above the DNSP's in order to drive this in the most efficient way.

What are the boundary points in the transformation pathways that RACE should work **within**?

In each of the scenarios, EV and charger OEMs were not seen to limit uptake or the V2G solutions made available. They have the know-how to build V2G technologies already and simply provide the desired technology should a market exist to buy it. This sentiment was also held by those representatives of OEMs interviewed as part of this project.

We therefore see little value in RACE focusing on these sectors, or pushing the introduction of these technologies into Australia.

Retailers are also already aware of the potential solutions and enough trials are underway to demonstrate the benefits of V2G to those that are interested in developing market offerings which EV owners will find attractive. Apart from ensuring there is an easy place for potential retailers to access information from existing trials, we do not see trying to convince retailers to offer V2G solutions as a high impact effort for RACE.

All the above sectors represent obvious boundary points for RACE.

The only interaction with these groups that may prove useful is using them as a sense check to determine how effective other actions have been in making it easy for these actors to operate in Australia.

SECTION 02:
Discovery of market actors

Ecosystem stakeholder interviews and opinions

Evenergi, in collaboration with RACE for 2030, carried out seven interviews and one group workshop with relevant stakeholders representing the following ecosystem sectors:

- Energy network regulators
- Government strategy and sustainability agencies
- Research sector
- EV owners
- EV OEMs
- EV charging equipment OEMs
- Home energy management services OEMs

The interviews sought opinions on:

1. the likelihood of a fully integrated EV or grid ecosystem by 2030
2. the three key actions that need to happen to get to this fully integrated state
3. their role in the ecosystem
4. the commerciality required to enable a strong value proposition to customers and a sustainable business model for providers

Interviews were conducted in the context of anonymity to ensure honesty of opinions so the following key insights represent those across the interviewees but are not associated with any individual or organisation.

Key takeaways include:

1. All stakeholders stated the importance of system integration as the most important factor to accelerate the uptake of V2G. Key factors that were considered important to achieve full integration include:
    a. Increase the supply of EVs, by introducing policies such as fuel standards
    b. Inbuilt bidirectional charging capabilities are expected to be part of most new cars currently in design (on sale from circa 2023-2024)
    c. Creating business models that are commercially viable and offer benefits to consumers
    d. Standards to ensure hardware and software interoperability
    e. Full integration requires synchronised market design and seamless integration for businesses to operate across Australia

2. Stakeholders believed the value proposition offered to EV owners will be critical in driving uptake. Value will be created by:
    a. Making the offer simple to the end consumer
    b. Ensuring the consumer feels they retain control over the charging
    c. Undertaking tariff reform
    d. Enabling retailer/aggregator/V2G provider to create value and share it with customers
    e. Introducing policies and subsidies to support uptake
    f. Standardisation, interoperability and streamlining the registration process

3. The majority of stakeholders considered that retailers/aggregators will drive the uptake and form the necessary partnerships to bring end to end solutions together, but DNSPs will play an important role in enabling this to be efficient.
    a. Existing actors are not likely to change their business models quickly, but were interested in partnering with others to offer new services.
    b. DNSPs play a role by unlocking the network value proposition through tariff reform and creating paid services the new retailers can fulfil to help them manage the grid
    c. Technology companies play a role by optimising and bringing together the hardware and the software, and providing the platforms that allow access to value streams from the different markets.

4. Bidirectional chargers are still too expensive to make a commercially viable value proposition for most consumers:
    a. Prices are expected to fall from $10,000 to less than $5,000 in the next 5 years. Ford already offer V2G technology for circa US$5,000 in the US[1].
    b. Scale will be important to drive down the cost of chargers
    c. Integration of solar inverter and bidirectional charging could eliminate duplication of similar hardware saving money and space for consumers

[1] https://www.ford.com/trucks/f150/f150-lightning/features/ev-charging/ford-charge-station-pro/

Stakeholder groups and their level of influence

The market sectors used to group all the actors were developed in conjunction with industry experts through our workshop and interviews. The final listing included:

- EV OEM's
- Charger and HEM OEM's
- EV Owners
- Research and funding organisations
- Regulators and standards bodies
- DNSP's
- Energy retailers
- Energy aggregators

Methodology for assessment of influence level

A multi-criteria assessment process was undertaken using both qualitative and quantitative data collected which is described in the diagram below.

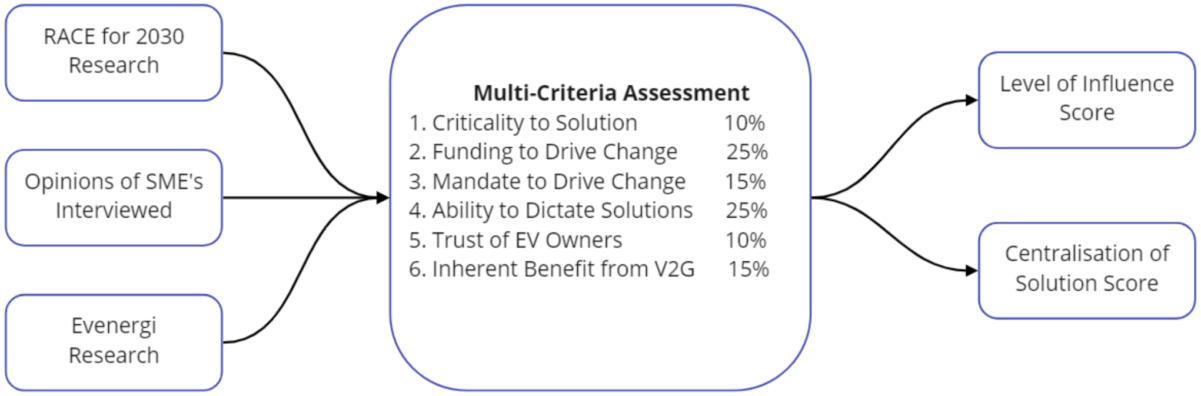


Figure 6: *Summary of multi-criteria assessment process used to assess influence*

The table below details the scores given to each sector for each criteria. While this is a subjective assessment there are three clear standouts with the highest level of influence, followed by two mid-level influencers then the remainder of the sectors.

Sector	Criticality to Solution	Funding to Drive Change	Mandate to Drive Change	Ability to Dictate Solutions	Trust of EV Owners	Inherent Benefit from V2G	Ability to Influence Score	Centralisation of Solution Score
DNSPs	8	7	9	9	6	10	8.3	8
Market Regulators	10	8	9	9	7	8	8.5	7
Governments (Funding)	7	10	8	9	8	7	8.5	3
Retailers	9	5	6	7	8	6	6.5	2
Fleets (Government)	5	8	7	4	10	8	6.8	3
Fleets (Commercial)	5	3	5	3	10	8	5.0	1
Private EV Owners	5	4	5	3	10	8	5.2	1
EV OEMs	9	5	5	3	7	3	4.8	2
EVSE OEMs	9	3	5	3	8	3	4.4	2
HEMS OEMs	5	3	5	3	8	7	4.6	2
Weighting	*10%*	*25%*	*15%*	*25%*	*10%*	*15%*		

Table 3: *Scores assigned for each criteria in assessment and results*

These conclusions are not materially different from those noted in other RACE research so a detailed explanation of why these sectors have such a level of impact is not expanded upon in this section.

Should further detail be sought then it can be found in the RACE report titled "N1 EV Opportunity Assessment Report FINAL_0511202", which can be found on the RACE for 2030 website. Further research conducted by Evenergi as part of the background to this project can also be found in an Addendum to this report titled, "Further EV to Grid Ecosystem Research".

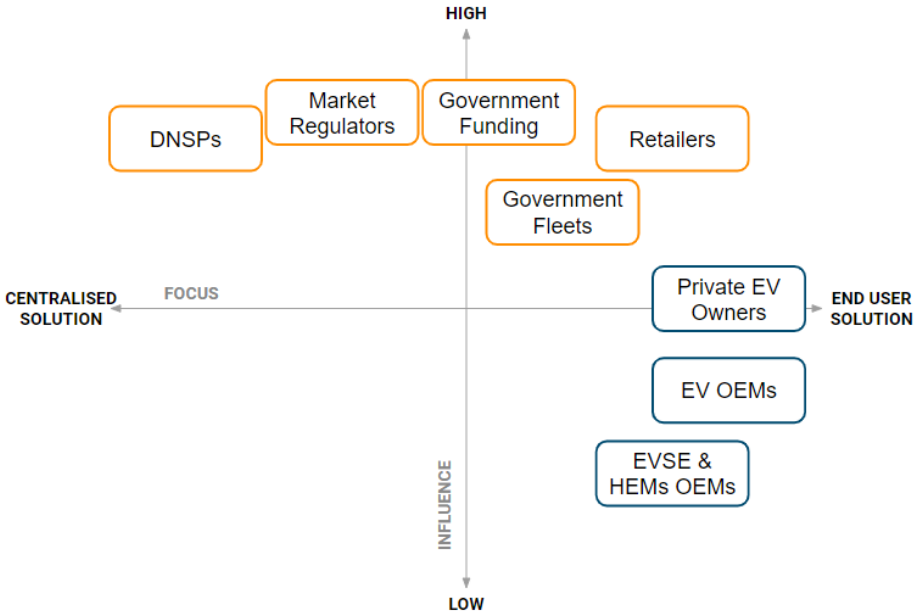


Figure 7: *Summary of level of influence scores from assessment and solution focus*

The most influential actors within each sector

Determining the actors within each sector and their level of influence relative to their peers was a new piece of research. The full list of actors was developed initially from Evenergi knowledge and research, with this list then reviewed in our workshop and interviews with ecosystem SME's to ensure a comprehensive coverage of all key actors.

Influence versus their peers was based on:

1. Existing roles in pilots and other forums driving EV to grid integration
2. Company public statements regarding leading Ev to grid solutions
3. Presence in the geographic locations and connection to the types of EV owners expected to be more likely to adopt EV to grid solutions

Given the market development is still in its infancy, this ranking could easily change as it develops. Through its research partners RACE should continually be keeping an eye out for new actors entering the fray who are bullish on driving forward EV to grid adoption.

Figure 8 on the following page depicts all the main actors noted from this work with their distance from the centre representing their perceived level of influence. The map shows the sectors seen to be most influential having their actors closer to the centre as a group. The individual actors within each group are positioned so those involved in trials and proactive activities already are closer to the centre than their peers.

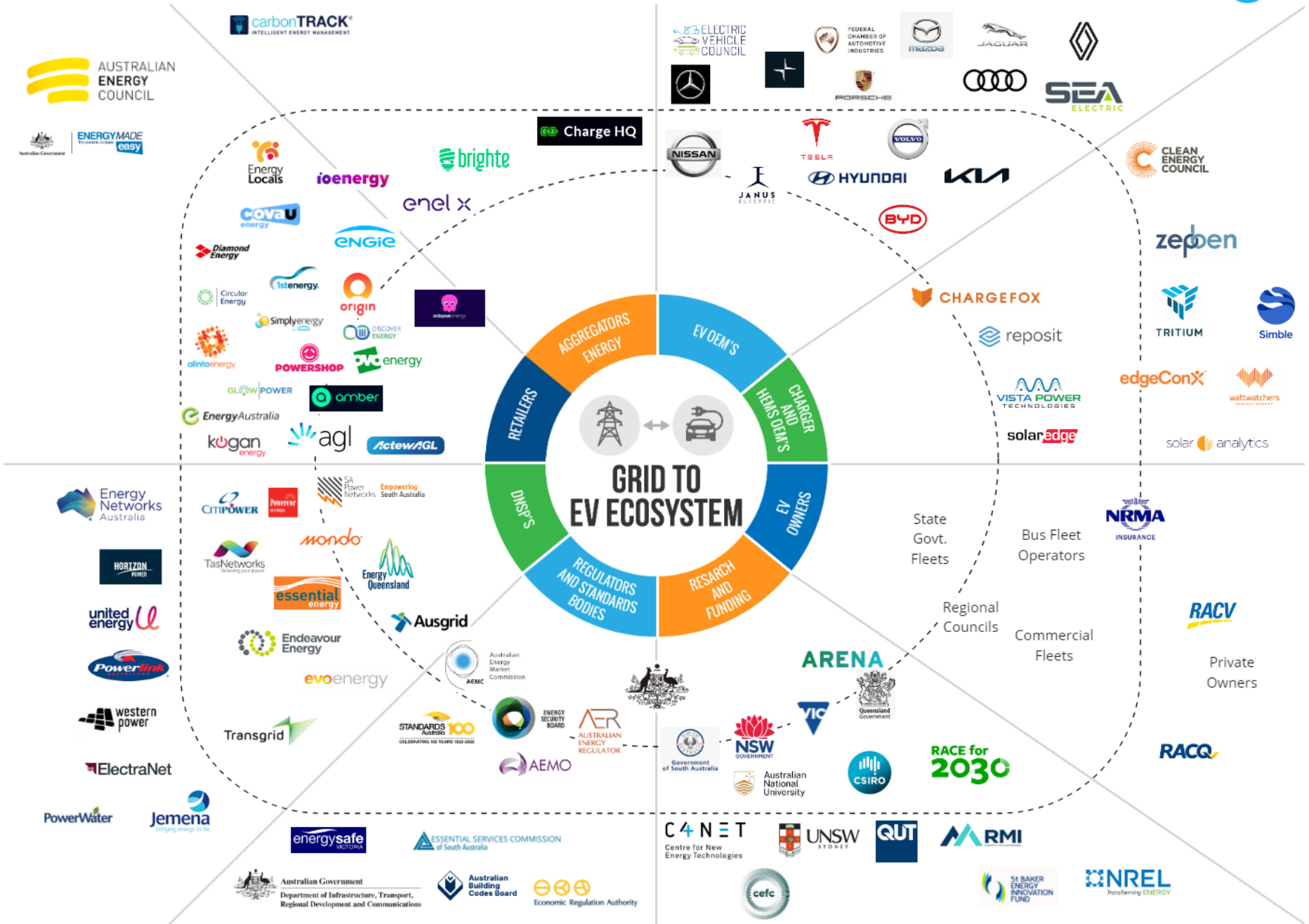


Figure 8: *Actors within the EV to Grid ecosystem and their level of influence (closer to centre = greater level of influence)*

SECTION 03: Causal pathway mapping

Using Causal Pathways

Causal pathways are a logic sequence of cause and effect predictions used to model how different scenarios could potentially impact the end state of an ecosystem. In this project the causal pathways technique was used to try to understand the impact of different actors leading the transformation on how the EV to grid ecosystem ultimately looks.

This helps us understand what could drive the ecosystem to different end-states, what those end-states might look like and how they differ in value creation and equity from EV to grid integration. We can then tie the RACE research themes to the critical turning points in the causal pathways to help us understand where and with whom RACE would gain the most impact from its work.

The project considered three different causal pathways, each mimicking different rollout pathways for similar technologies. The pathways were chosen to be materially different from each other and accentuate how these differences could manifest themselves in the end-state ecosystem. In reality, it is likely elements of all three scenarios will exist in the actual end-state ecosystem, but which is more dominant is likely to be set by the evolutionary pathway taken. The differences here are pronounced to draw out which actors' influence is most aligned to what RACE wants to achieve.

Each causal pathway starts with a trigger event, and an assessment of the effect this has on the ecosystem. The next most logical reaction, or cause, is then deduced and then what its effect will be. This process is continued until a steady state ecosystem achievable by 2030 occurs.

The three trigger events which define the scenarios are:

1. **Retailer led transformation** - where one or more retailers develop a way to work around the current regulatory gaps and inefficiencies to bring technology to market in a similar way to how Virtual Power Plants (VPPs) came to market;
2. **Government incentive led transformation** - where federal or state governments see the value in V2G adoption and place a large subsidy on a V2G charger making it accessible to all EV owners in a similar way to how the rebates for installing rooftop solar PV worked; and
3. **DNSP led transformation** - where one or more DNSPs mandate a level of EV to grid integration at the time of connection seeing value for the grid in funding such a solution such as how SAPN has mandated Authorised Agents for control of PV installations in SA.

The findings and insights for each causal pathway are shown in the following sections.

Scenario 1: Retailer led transformation

This causal pathway is triggered by one or more retailers entering the Australian market with a smart or V2G charging offering such as what Octopus and OVO Energy have brought to market overseas already.

It relies on them finding a way to build an integrated solution which allows them to reduce their wholesale energy costs and/or create other revenue streams using their customers' EVs to offer energy to an EV owner at a lower rate than can be done with the service.

This scenario starts with a basic energy arbitrage controller making use of on-site solar and Time of Use (ToU) tariffs to minimise the cost of charging the EV. While this solution is very basic it does represent good value to the EV owner. It does not require a currently very expensive V2G charger and the difference in rates from a flat tariff to an off-peak one can represent a saving in the order of $837 per annum using the assumptions below:

Saving from charging on ToU = Annual average energy x difference in rates

A typical driver completes 15,000 km per annum which equates to circa 3,000kWh.

A typical flat fee tariff is in the order of 37.7c per kWh[2], while a typical ToU off-peak rate is 9.8c per kWh[3].

Saving from charging on ToU = 3000kWh pa x (37.7c/kWh - 9.8c/kWh)

= $837 per annum

This could be achieved with a basic smart charger, which in a typical domestic environment can be obtained and installed for circa $2,500.

Currently, only one bidirectional charger has been imported into Australia (Qasar Wallbox) and it costs $10,000 to purchase. This creates a blocking point for the ecosystem to progress any further as while there are further benefits (estimated at $300-$600 per annum per charger[4]) that can be achieved with a bidirectional charger, in most cases they will not come close to offsetting the significantly higher upfront cost.

This is noted by the first orange “Post It” in Figure 9 below and requires only the acceptance of ToU, which with the compelling numbers above give a retailer room to work with for a home charging an EV.

[2] https://www.agl.com.au/-/media/aglmedia/documents/help/rates-contracts/market-contracts/2020/07/2020---agl-sa-elec-website-pricing-v7.pdf

[3] https://www.powershop.com.au/app/rates/aer/electricity/residential/ev/sapn/combined-all.pdf

[4] https://arena.gov.au/projects/agl-electric-vehicle-orchestration-trial/

Figure 9: *Causal Pathway, scenario 1 - Customer value for V2G defined (as per VPP Rollout)*

In order for the ecosystem to progress to a more fully integrated solution, the economics must be improved and this represents a key focus area for RACE.

Firstly, we see the price of a bi-directional charger must come down. Overseas, Ford have already stated they will be selling a bidirectional charger as an optional extra with the F150 EV for $US1,350[5], noting this charger provides a DC supply only. Ford is also offering a very powerful inverter/controller package that coupled with the charger can independently power a home for an additional $US3,895. This is more than would be required to simply have the ability to push 7kW of power to and from the vehicle but even so Ford is already offering all this for circa $US5,000. This demonstrates that the cost of V2G capable chargers can be brought down, even at what is still a relatively small scale market. Using RACE's research to help convince governments of the benefits of bi-directional chargers and that an incentive early on could bring the price of V2G chargers close to single directional smart chargers, which would accelerate uptake and help the market achieve the economies of scale to lower prices without subsidies in the future.

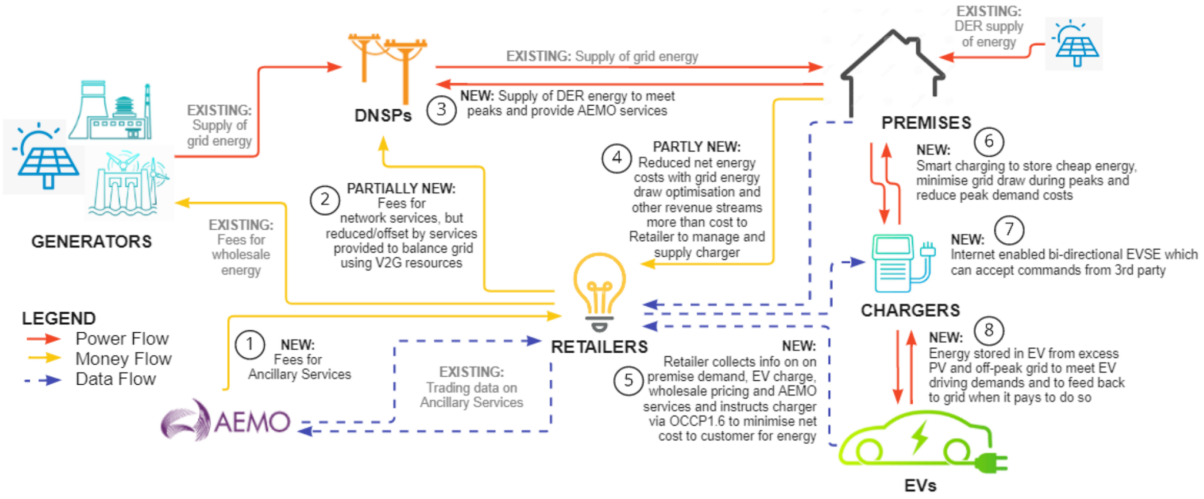
Secondly, we do not yet have the national rules in place for small scale aggregators to participate in wholesale market services. This creates additional restrictions and inefficiencies on retailers to get the most from a bidirectional charger, which in turn limits the savings they can offer their customers. RACE should be using its research to work with entities such as the Australian Energy Market Operator, Energy Security Board, and the Australian Energy Market Commission to streamline market participation regulation and Energy Networks Australia and the Clean Energy Council to create national standards aligned to international common practice for equipment certifications.

As shown in Figure 9, we do foresee the above requirements happening prior to 2030 and this ultimately paves the way for retailers to have the full gambit of services a bi-directional charger can enable at their disposal.

We foresee the competitive nature of the retail market pushing retailers to offer cheaper and cheaper total energy costs to their customers and this will only be achieved by unlocking all of the revenue streams from energy arbitrage and ancillary services they can. This leads to an end-state solution which looks like the diagram shown in Figure 10.

In this solution the retailer manages the sophisticated control systems and market interactions to optimise energy costs, with the home/EV owner simply seeing a low total energy bill from the retailer.

[5] https://electrek.co/2022/03/01/ford-launches-bi-directional-home-charging-station-surprisingly-good-price/



Point of Interest	Key Factors	N1 Research Roadmap / area of influence
1	Retailers provide AEMO ancillary services via their aggregated stored energy capacity in customer EVs creating previously unavailable revenue streams to offset raw energy costs	Research which influences the uptake of internationally endorsed standards is key Integrated opportunities - exploring regulatory and other constraints, and Regulatory and Coordination - stds and protocols for bi-directional chargers, interoperability and coms
2	Retailers provide grid stabilisation services to DNSPs which partially offset network charges and reduce total energy costs for customers	Valuing DNSP services and creating a market for retailers to provide them along with tariff reform research are the key items for RACE here from above research themes
3	More control over two way energy flow with EV buffering solar and home demand peaks	None - this is an end result of other changes
4	Reduced energy costs through arbitrage and auxiliary services	None - this is an end result of other changes
5,7	Retailer monitors home demand and EV state of charge acting as home energy manager	Interoperability is important here to allow switching so above mentioned regulation and coordination research is key
6,8	V2H energy flows using EV as stationary battery to store solar and reduce grid draw during peaks	Research which demonstrates the value to EV owners and the community from bi-directional chargers is key in driving government incentives and public uptake Data and technology - EV trials, and Integrated opportunities - business models

Figure 10: *End-state ecosystem for scenario 1: Retailer led causal pathway*

Scenario 2: Gov. incentive led transformation

This causal pathway is triggered by a government led introduction of generous subsidies to reduce the purchase cost of bidirectional chargers, making a V2G roughly the same price as a single direction smart charger and therefore a compelling value proposition to any EV owner purchasing a charger.

This creates a different ecosystem to that of scenario 1 as it does not require a sophisticated entity such as a retailer to be working the bi-directional charger as hard as they can to maximise returns. It would provide EV owners with a solution that they can use as much as they please. Based on multiple overseas studies noted in previous RACE research we conclude this will result in most EV owners sticking to the basics and they would utilise their EV in a similar way stationary batteries are currently used to store their solar, and offset peak demand.

As noted in scenario 1, full V2G solutions are expected to create a further $300-$600 of value EV-charger per annum, but would require a sophistical command and control system to be added to the EV owner's solution to enable this. Based on Authorised Agregator service costs in SA, this is estimated to cost $150 once scale is achieved by the operator. The EV owner also has to concede a significant level of control over when their car is charging and discharging, submit the vehicle to more charging cycles and many owners would not understand how the energy market works well enough to be confident they understand the increased risks and benefits the solution offers.

We therefore conclude in this causal pathway that many EV owners will simply use their charger to provide V2H services and this is represented in Figure 11 on the following page.

While not a full V2G solution, it still does offer benefits to the grid and is a valid pathway to getting EV to grid integration accelerated. RACE could use its research to drive public demand and government interest in creating such an incentive. We would feel RACE gains the most impact from its research though in highlighting the benefits of V2G over V2H as an end-state and should use its research to influence all parties in this direction.

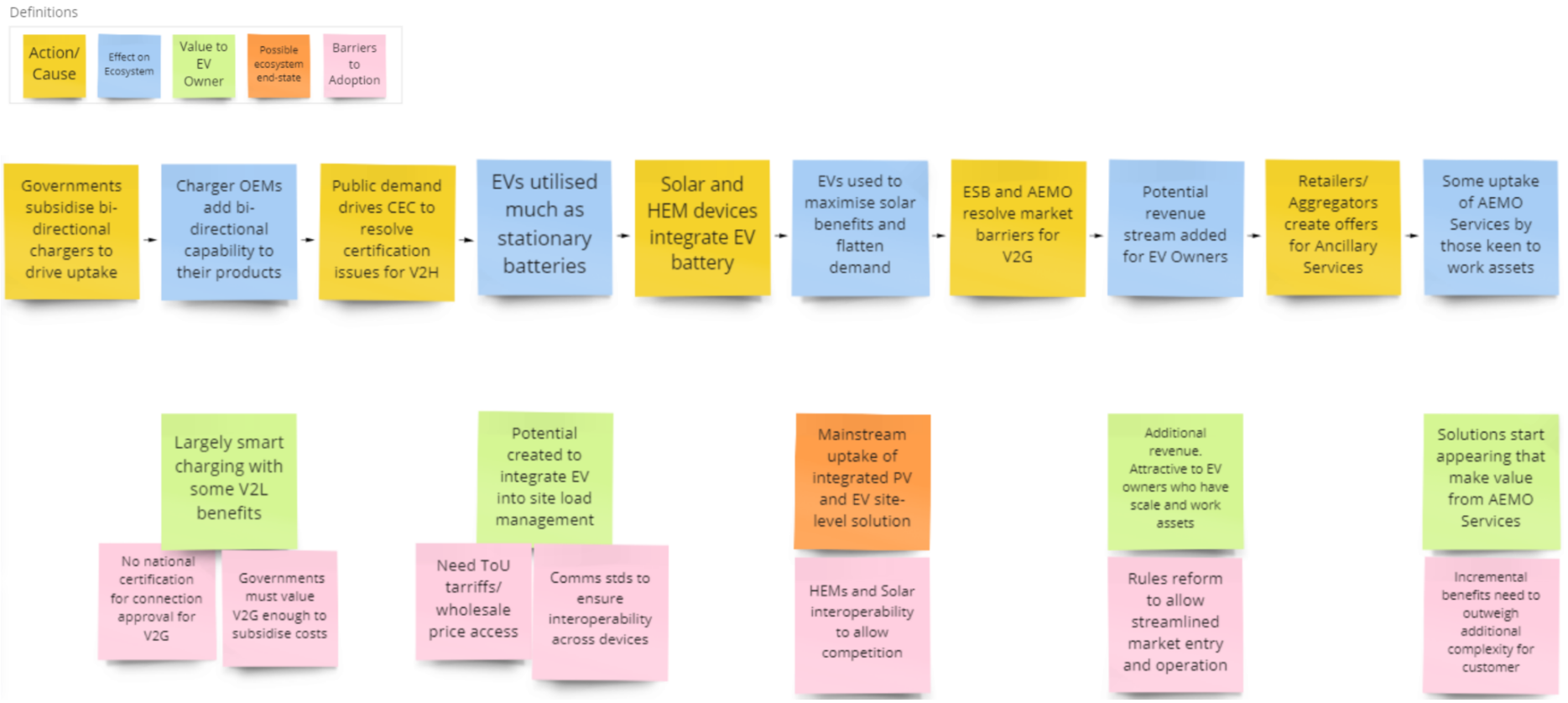


Figure 11: *Causal Pathway, scenario 2: Government incentives led solution*

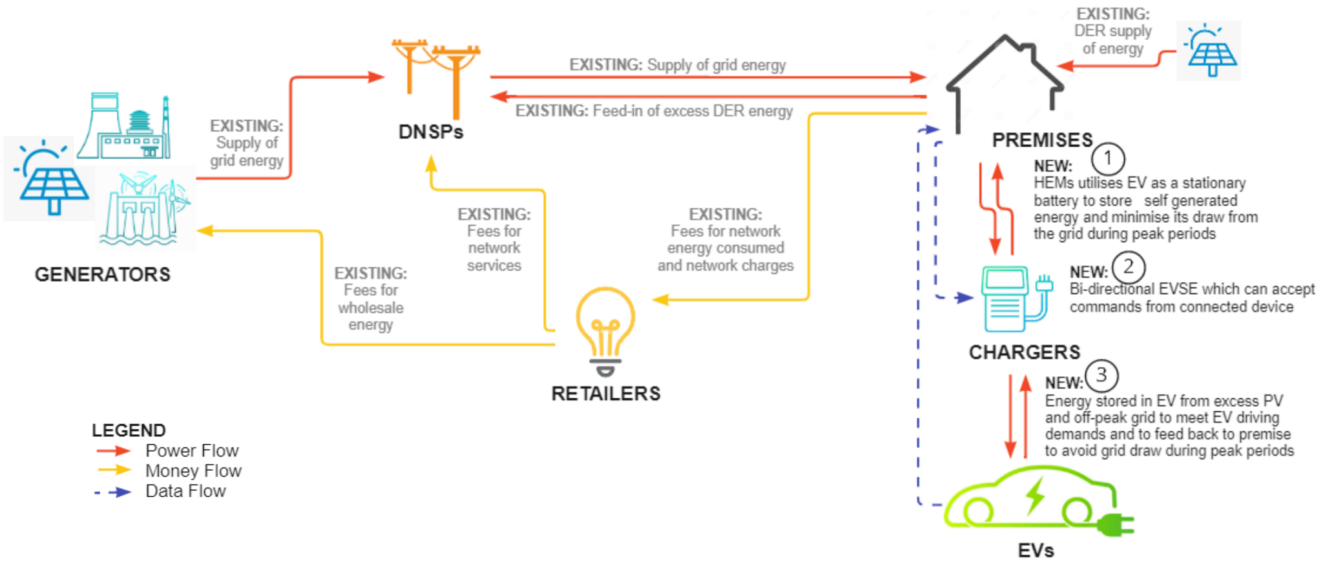
To incentivise the uptake of bi-directinoal chargers via government subsidies, the value of such subsidies to society must be determined. Intuitive value is derived by triggering economies of scale, leading to a faster price decline of bi-directional chargers, which will in turn enhance the network benefits of bi-directional charging. Using the network efficiently creates benefits for the whole of society. Quantifying network benefits and societal flow-on effects is complex, encompassing a number of RACE's research areas, e.g., charging implications, New EV/grid business models, and customer behaviour. Providing governments with research that outlines the extent of a market failure will encourage governments to step in.

We assume that the subsidy payment triggers an increase in demand for bi-directional chargers, which will encourage EV charger OEMs to add bi-directional charging to their existing capabilities. The subsidy and education campaign by the government triggers an increase in all types of EV chargers, and speeds up the resolve of the certification and standardisation issue.

We also anticipate that only larger EV fleets owners, who have the scale to manage the increased complexities of innovative business models will look to adopt full V2G services. Due to the lack of mainstream scale this offers we see V2G staying as more of a specialist service for retailers under this scenario.

On the regulatory side, market reform that is currently underway affects all DER and facilitates innovations that fit within demand response, grid services and small distributed generators. The objective of these reforms is that cost-reflective pricing should enable demand response and encourage flexibility to maximise network benefits, including V2G market participation.. RACE may want to support faster regulatory reform to encourage the realisation of the benefits under this scenario.

The end-state of the scenario is outlined in Figure 12.



Point of Interest	Key Factors	N1 Research Roadmap / area of influence
1,3	Behind the meter demand and supply optimisation by using the EV battery as its storage system. Reduces customers' electricity bills by minimising the need to draw electricity from the grid, especially during peak periods. Excess generation fills up the EV battery to either meet demand during peak periods or meet driving demands.	Research which demonstrates the community value of V2G and would warrant a significant investment by the government to cultivate grid integration of EVs. Data & technology - EV trials with whole of network approaches Integrated opportunities - New EV/Grid business models Research which influences the uptake of internationally approved standards with national consistency. Integrated Opportunities - exploring regulatory and other constraints, and Regulatory and Coordination - stds and protocols for bi-directional chargers, interoperability and coms
2	To optimise supply from roof-top generation and demand, bi-directional chargers, which accept commands from connected devices are now deployed.	

Figure 12: *End-state ecosystem for scenario 2: Government incentive led solution*

Scenario 3: DNSP driven transformation

This scenario assumes a DNSP led change by enforcing new rules for the connection of smart and bidirectional chargers to the grid. It assumes that technical standards, comparable to those brought in by SAPN for PV and proposed for smart chargers, are now in operation across all DNSPs, and include:

- Direct control by the DNSP to disconnect and reconnect during times of emergency
- Smart meters to be able to separately measure and control generation and any controlled load
- DNSPs provide signals to an Authorised Agent which indicate when they want chargers to ideally absorb or discharge energy based on grid requirements.

In reality, the signals from a DNSP would largely align with the price signals the retailers would use in scenario 1 to determine when it is best to charge the EV or push power back to the grid so the energy flow behaviours that occur under both would be similar most of the time. The big difference we foresee with this solution is the fact that it is mandatory. This takes away the choice for the EV owner, which would likely hurt positive engagement and it removes the competitive tension between retailers which drives innovation.

The value to the EV owner and the community are very similar to that of scenario 1, with DNSPs expected to have the sophistication to incorporate all types of benefits V2G can offer into their solution. Their grid-focused view however may mean that the optimisation algorithms do slightly favour the grid over the individual which may mean the EV owners see less of the benefit directly. The lack of innovation in solutions that the competitive retailer-led transformation would bring may also result in the ecosystem squeezing less value out overall too.

Mandatory involvement though is not thought to be such a large issue that it would stop someone purchasing an EV so while an EV owner might grumble to start with, it isn't expected to lower overall EV uptake and therefore this solution is expected to end up with the most EVs fully integrated into the grid.

This means that while this scenario has less focus on innovation, it does have scale and this could result in it being the most impactful on the grid and hence to the community out of the three scenarios.

This solution also requires charging equipment OEMs to make alterations to their equipment so it complies to the control system the DNSPs develop and this would move Australia's requirements away from international standards and may reduce competition in the bi-directional charger market.

Figure 13 provides an overview of the causal pathway of a DNSP led transformation.

Figure 13: *Causal Pathway, scenario 3: DNSP led solution*

Technically, this solution requires all the same elements to be put in place that scenario 1 required, the only difference is an authorised agent of the DNSP is controlling the chargers rather than a retailer.

This means the areas where RACE's research could help to accelerate the uptake of EV to grid integration under this scenario are the same as described in scenario 1. Possibly with the DNSPs driving the solution they might feel more ownership to resolve the interoperability issues which exist today and less influence would be needed by RACE to help resolve this.

Under a scenario such as scenario 3, we see RACE's research having the most impact in influencing the DNSPs and the CEC to ensure what standards they set for chargers and EVs to be approved for connection to their control systems and the grid conform with international standards and our created as singular national standards. This will be important to ensure interoperability, simplicity in the solution and also ensure OEMs are not discouraged from entering the Australian market by differences they must build into their products in order to achieve certification.

RACE's research themes titled Integrated Opportunities and Regulatory and Coordination both speak clearly to these requirements.

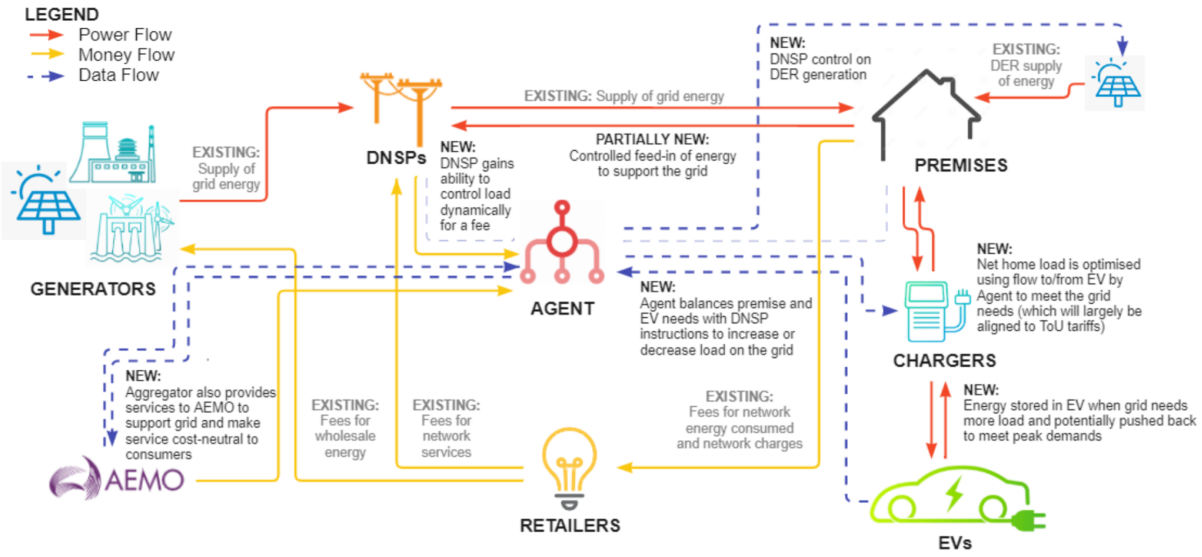
RACE also would have a role in influencing the grid versus. customer centricity of the solution so the right balance is achieved in sharing the benefits to help the grid, and incentivising EV owners directly enough to want to encourage them to engage in the ecosystem with their vehicle.

RACE's research into New EV/Grid Business Models and Customer and Culture Behaviour would be relevant to this endeavour.

Lastly, a mandatory system would need to avoid strong pushback from EV owners who are concerned participating in V2G will adversely affect their EV. It is still not proven how big this impact will be but our earlier interviews and research stated consumers are fearful of this so it needs to be addressed. We see this being resolved using a combination of limits imposed on what the system can do in terms of cycling batteries, but also in educating EV owners on the actual impact it has and the net benefits they gain.

RACE's research under the title Data and Technology would be valuable here and as noted previously we think the most impact would be working with government fleet owners first, who are going to be more open to driving community benefit and feel less personally about the EV and its battery.

A summary of the foreseen end-state in this scenario and a summary of all the places RACE's research could assist in influencing the changes is shown in Figure 14 below.



Point of Interest	Key Factors	N1 Research roadmap / area of influence
1	The Authorised Agent collaborates with retailers and Aggregators to provide AEMO ancillary services via their aggregated stored energy capacity in customer EVs creating previously unavailable revenue streams to offset raw energy costs.	Research which influences the uptake of internationally endorsed standards is key Integrated Opportunities - exploring regulatory and other constraints, and Regulatory and Coordination - stds and protocols for bi-directional chargers, interoperability and coms.
2,3	DNSPs are using a more service oriented business model, procure network services but are also in control load dynamically.	Valuing DNSP services and creating a market for Retailers to provide them along with tariff reform research are the key items for RACE here from above research themes
4	More control over two way energy flow for DER generation, driving EVs to support holistic grid needs.	Research that helps define balanced business models and centricity would be important to ensure DNSPs do not introduce overly draconic controls
5,6	Agent balances premise and EV needs with DNSP instructions to increase or decrease load on the grid	Interoperability is important here to allow switching so above mentioned Reg and Coordination research is key
7	V2G energy flows using EV as stationary battery to store solar and reduce grid draw during peaks	Research which demonstrates the value to EV owners and the community from bi-directional chargers is key in driving government incentives and public uptake Data and Technology - EV trials, and Integrated Opportunities - Bus. Models

Figure 14: *End-state ecosystem for scenario 3: DNSP led solution*

SECTION 04: Conclusions

Which scenario should RACE pursue?

As stated earlier, we expect multiple solutions and elements will exist in the real-world ecosystem, but the causal mapping exercise above does highlight that the influence of different actors could have material impacts on the end-state ecosystem. This varies with the value generated, the equity of who benefits and also the grid's ability to absorb higher levels of renewables.

Below we have drawn out the key divergences we saw in the ecosystem modelling and highlight the actors RACE would want to influence, and which research streams proposed in the Opportunity Assessment would be most relevant to guide the ecosystem's evolution in one direction or another.

1. **Smart charger vs. bi-directional charger**
   If the ecosystem does not get to a point where the cost-benefits of a bi-directional charger outweigh those of a one way smart charger optimising charging costs then the level of EV to grid integration is constrained and while still a benefit to the owner and community, opportunity is still left on the table.
   In all scenarios ***government incentives*** create the tipping point and help OEMs get to the scale and efficiency required to create a sustainable, value-adding solution. We see using RACE research on the benefits of V2G as critical to influencing the government (and public) to support bi-directional charger and accelerate the evolution of the ecosystem (Data and Technology research theme)

2. **V2G vs. V2H**
   V2H solutions can create full energy arbitrage solutions, where cheap solar and off-peak energy can be stored and used when the grid wants to lower demand. Full V2G enables greater grid balancing potential adding the ability to supply local areas of demand and provide auxiliary services to support power quality management. These add further value to the grid, community and EV owner, but the benefits are less tangible. Our causal pathway analysis suggested that if EV owners adopt a V2H solution, and then advancing to V2G is optional, uptake of V2G may be hampered.
   The structure of ***government incentives*** and ease with which retailers and other 3rd parties can create ***efficient solutions*** which can extract benefits from the ***wholesale and ancillary services markets*** with their aggregated storage will drive whether the V2G gains prominence or the ecosystem mostly plateaus at V2H. Leveraging RACE research with regulators such as the AEMC, ESA and AEMO would have a significant impact if it helps in agreeing national standards that support new market entrants and participation by V2G aggregators. Research themes of Integrated Opportunities and Regulatory and Coordination are relevant to the cause.

3. **Centrally vs. customer led**
   In practice, the two scenarios representing a centrally driven evolution and a customer centric driven one ended with a very similar looking ecosystem just with the DNSPs setting the preferred charging and discharging windows in one, and market pricing signals doing it in the other. The main difference is that if a centrally driven solution was mandated, it could end up with a greater uptake of a slightly more grid-centric solution. As long as EV owners see enough direct benefit to not revolt, then this solution could provide the largest impact to the grid and community.
   The ***connection rules DNSP's set*** for charging equipment will be critical to this solution, both in making the solution palatable to EV owners that are obliged to participate, but also for charging equipment OEMs who will need to make sure they can make their products comply before entering the Australian market. RACEs research into New EV/Grid Business Models and Regulatory and Coordination would be relevant and should be used to influence regulators, DNSPs and the CEC to ensure customer centric, internationally confirming standards and connection rules are agreed.

How RACE maximises the impact of its research

The table on the following page shows the actors with which we conclude will be the most influential in the evolution of the EV to grid ecosystem and which of RACE's research themes would be most relevant in influencing and supporting them to accelerate the uptake of EV to grid integration.

We also conclude that EV to grid integration provides the largest overall, and most equitable benefits if the ecosystem can absorb renewables from across the grid, and provide power back to the grid to level demand and support power quality controls. This means solutions that progress to full V2G solutions are seen as the ones RACE should pursue to maximise the impact of their research and create the most equitable solutions.

Table 4: Summary of where and with whom RACE research themes would make the most impact

Sector of Influence	Key Actors	Focus recommended for RACE	N1 Research Roadmap
Government Funding 	ARENA State Gov. Climate Dept's AER	RACE will need to use its research into the benefits V2G can have on grid capacity, increased renewables penetration and power quality to ensure support. We see opportunities for direct incentives through governments or indirectly through AER allowances given to DNSP's to support such programs.	Research which demonstrates the community value of V2G and would warrant a significant investment by the government to cultivate grid integration of EVs. Data & Technology - EV trials with whole of network approaches Integrated Opportunities - New EV/Grid Business Models
Regulators 	ESB AEMC ENA CEC	We recommend RACE work with agencies developing the rules and standards for connection of V2G chargers to the grid and for aggregated storage provision of AEMO Ancillary Services and use its research to help influence decisions that support easy market entry and uptake vs. making it easier to operate the grid using today's paradigms	Research which influences the uptake of internationally approved standards with national consistency. Integrated Opportunities - Exploring regulatory and other constraints associated with the integration of energy, e-mobility and development Regulatory and Coordination - Standards and protocols for bi-directional chargers, interoperability protocols and coms
DNSPs 	SAPN, Ausgrid Evo, Mondo etc	As the other side of working with the AER to secure funding we see a role for RACE to help support DNSP's in making their cases for engaging in activities which accelerate the uptake of integrating EVs into the grid.	Influence DNSP governing bodies ensure they enforce adoption of consistent national standards rather than be DNSP specific. All above research categories for Regulators apply plus Market and Pricing - Tariff design
EV Owners 	Gov Ministers EVC	We believe government fleets provide an excellent starting place and RACE should focus on convincing gov transport mgrs to lead the adoption of this technology. General awareness via public campaigns and EV representative channels to public is also recommended	Research which informs customers perceptions of V2G and helps them understand the pathway to participation. Data & Technology - Charging Implications and EV Data Customer & Culture Behaviour
Retailers 	ActewAGL Ovo Octopus	Retailers are expected to know what they need to make attractive solutions but we see them as a good barometer of how well changes to the technical environment are working. RACE should form relationships with the retailers most keen on V2G as a way to refine what is needed most to make the ecosystem thrive.	Research which helps them refine offerings to EV owners. Noting though this is deemed helpful, but not as essential as some of the above stakeholder to influence.

How does RACE engage the key actors?

Most of the influential actors identified are discrete entities or centralised governmental overarching bodies that can coordinate and represent their members. This makes it relatively easy for RACE to interact with them to leverage research and influence.

The key exception to the above is EV owners. Public awareness campaigns will be useful but we suggest RACE focuses on a smaller number of large fleet owners as the first groups of EV owners to influence, with government fleets being a prime example given their size and also government's vested interest to support EV to grid integration.

Table 5: *Suggested ways for RACE to best engage with key actors*

Sector of Influence	Key Actors	Suggested Engagement Process
Government Funding 	ARENA State Gov. Climate Dept's AER	Federally, ARENA is key organisation to engage and work with to structure future incentives which drive renewables uptake The federal Minister for Climate Change and Energy and also the appropriate state offices would be key to gain support from too. The AER would not directly fund uptake, but influencing them to see the value in allowing DNSPs to invest in this as part of their regulatory submissions could prove a key way of getting DNSP engagement
Regulators 	ESB AEMC ENA CEC	All the government agencies mentioned to the left will be critical in streamlining the backbone rules and regulations for EV to grid solutions and must each be engaged and influenced. ESB and AEMC for market entry rules for aggregated storage devices CEC for internationally standardised certifications and interoperability
DNSPs 	SAPN, Ausgrid Evo, Mondo etc	Individual DNSP's should be engaged along with the ENA in order to maintain a nationally coordinated response, but excite a handful of DNSPs to progress with larger scale and bolder trials to encourage uptake
EV Owners 	Gov Ministers EVC	A number of states, including NSW, ACT and Vic are already well positioned with EV transition plans underway and engaging in them to trial EV to grid solutions would offer an excellent way to accelerate uptake and would require interaction with relevant Ministers and state environment and climate change offices. Public awareness should be bolstered by providing touch points for EV owners with educational materials from RACE's research to build public ground support which will guide political priorities. Working with EV OEMs to engage owners at the time of purchase is thought to be the most effective point.
Retailers 	ActewAGL Ovo Octopus	Retailers are not expected to need influence. Retailers already exist keen to pursue these solutions so offering any Retailer support is thought to be the best way to engage with them and to also learn how effective changes are in streamlining their ability to provide solutions.